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DIRECT TESTIMONY OF DR. HARRY H. WEST

- 1 Q. Please state your name and business address.
- 2 A. Harry H. West, Shawnee Engineers, 1829 Augusta #10, Houston, Texas 77057.
- 3 Q. What is your profession?
- 4 A. I am an independent consulting chemical engineer.
- 5 Q. Do you also maintain an academic affiliation?
- 6 A. Yes. I am an Adjunct Professor of Chemical Engineering at the Process Safety
- 7 Center of the Texas A&M University
- 8 Q. Please summarize your educational background.
- 9 A. I received a BS from the Bucknell University in 1965; and a PhD from the
- 10 University of Oklahoma in 1969, all in Chemical Engineering.
- 11 Q. Dr. West, do you have a particular area of specialization within chemical
- 12 engineering?
- 13 A. Yes, my primary specialization is in process safety, with a particular emphasis on
- the analysis of safeguard systems that can avoid or mitigate the consequences of a
- 15 chemical release.
- 16 Q. Do you regularly do research, publish, and speak at professional symposia on
- 17 those subjects?
- 18 A. Yes. A listing of my publications and symposia presentations is included in the
- 19 Resume attached to this testimony as Exhibit A.

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- 1 Q. Are you a registered professional engineer?
- 2 A. Yes. I am a registered professional engineer in the States of Pennsylvania and
- 3 Texas.
- 4 Q. Describe your experience in LNG technology.
- 5 A. In the late 1960s, my first involvement in LNG technology was to develop a
- 6 computer simulation of the LNG liquefaction process for the ChemShare
- 7 Corporation, which allowed design engineers to optimize process conditions. As
- 8 a member of the professional staff of University Engineers of Norman Oklahoma,
- 9 I was involved in many aspects of LNG technology. In the early 1970s, I
- participated in the LNG safety research projects sponsored by the AGA and
- others, which involved LNG spills on both land and water. Experiments to
- 12 evaluate the effectiveness of LNG fire control technologies were also a major
- project. Troubleshooting many early LNG peak shaving facilities led to
- numerous process developments, most notably the running film LNG vaporizer
- 15 (currently used by many LNG peak-shaving facilities) and the patent on fire
- 16 control of LNG tank vents.
- 17 I participated in numerous LNG safety analysis studies for proposed LNG
- importation terminals throughout the USA during the 1970s, including the
- successful projects at Cove Point, Elba Island and the Trunkline terminal in Lake
- 20 Charles. For LNG liquefaction projects in the Middle East and Far East, I
- 21 participated in safety analysis studies and detail design of the fire control
- 22 safeguard systems.

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One significant aspect of LNG safety analysis studies was the production of a 1 2 document, which detailed the compliance of the proposed detail facility design to each paragraph of the NFPA 59A standard. The last such document I produced 3 4 was in 2000 for the Dhabol India LNG importation terminal. 5 Q. What is your current focus in LNG technology? 6 I am currently updating my LNG safety text, originally prepared in the late 1970s A. 7 with my partner, the late Dr. Lester Edward Brown. It is anticipated that this text 8 will be used for a one semester academic course at the Texas A&M. Doha, Oatar 9 campus. Notes from this text have been used in continuing education courses on 10 LNG/LPG safety presented in the Far East for many years. 11 I am also involved in directing Texas A&M graduate students and visiting 12 professors in several LNG research projects, specifically various Computational Fluid Dynamic models, design of fire control experiments, and development of 13 14 updated LNG rollover mathematical models. Have you ever served as a consultant either to government standard setting 15 Q. agencies or to government officials working in areas bearing on LNG safety? 16 17 A. Yes. In the mid 1970's, University Engineers had a project to advise the US Coast 18 Guard on the development of LNG regulations. As a senior consultant on this project, I visited LNG terminals in Algeria at the behest of the US Coast Guard, 19 20 and subsequently co-authored the report to the Coast Guard containing recommended practices regarding LNG ship to shore transfer and dock fire 21 22 fighting options.

Exhibit	

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1		Also in the mid 1970s, I was a member of the University Engineers technical
2		team that provided LNG consulting services to the Federal Power Commission.
3	Q.	For whom are you appearing in this proceeding?
4	A.	I am appearing on behalf of a coalition of Cities in both Massachusetts and Rhode
5		Island, each of which would be impacted directly by either the KeySpan or the
6		Weaver's Cove proposals.
7	Q.	When did your work for the Cities first commence?
8	A.	I was first contacted by Garry Bliss on behalf of the Mayor of Providence, RI, in
9		late 2004.
10	Q.	Dr. West, when you were first contacted by representatives of the Mayor of
11		Providence, were you told that your help was wanted in fighting the certification
12		of the LNG proposals?
13	A.	No, I was asked to assist the various city staff, most notably the Providence Fire
14		Department, in evaluating the safety aspects of the Keyspan proposal.
15	Q.	Dr. West, please summarize the conclusions that you reached following your
16		evaluation.
17	A.	While working with the Providence Fire Department, I became acutely aware of
18		the deficiencies in the FERC safety analysis. During my review of the Keyspan
19		draft environmental impact statements (DEIS), I had numerous technical
20		discussions with Dr. Jerry Havens. My analysis of the LNG safety aspects of the

Keyspan DEIS concurred with Dr Havens review. My testimony herein will focus

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Exhibit	

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- on several issues that complement and perhaps expand some of the concepts

 detailed by Dr. Havens.

 Was your work subsequently expanded to include the Weaver's Cove proposal?
- 4 A. It was. The analysis that follows, and the judgments I offer, apply equally to the
- 5 Weaver's Cove and KeySpan proposals.
- Q. You mentioned your concurrence with the views being offered by Dr. Havens in
 this proceeding. Please explain what you mean by that concurrence.
- A. As Dr. Havens was in the process of preparing his testimony, he wanted to test his analysis and judgments in a "peer" review fashion. He asked that I undertake a critical review of his work. I did, and following that review I told Dr. Havens that I was in total agreement with the views and judgments expressed in the testimony that he is sponsoring.
- Q. Dr. West, will you explain the concerns that you have regarding the failure of the FERC LNG safety analysis?
- 15 A. The issues which I will present herein are:
- Inadequacy of the thermal hazard exclusion zone analysis
- Lack of consideration of modern concepts of Process Safety
- Inadequate consequence modeling
- Potential use of high expansion foams systems to reduce the thermal

 hazard exclusion zone estimates for LNG terminal impoundment areas.
- 21 Q. How are the criteria for thermal radiation hazard exclusion zones inadequate?

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1 A. Ouantification of the LNG pool fire hazard exclusion zone involves calculating 2 the distance from the fire at which thermal radiation levels are hazardous to 3 people and equipment. NFPA59A and the DOT 49CFR193 use the same basic 4 concept to define the thermal hazard exclusion zone (minimum separation distance) from LNG impoundment areas to the nearest edge of the LNG facility's 5 6 property line or the nearest point of assembly where the thermal flux is 1.600 BTUs/Hr-Ft² (5 kW/m²). 7 8 This level of thermal hazard is far too high to provide for the congressional intent 9 in the Pipeline Safety Act of 1979 (codified as 49 CFR part 193), which was 10 "protection of persons and property near an LNG facility from thermal radiation 11 caused by ignition of a major spill of LNG" 12 Q. What is the impact on people from a thermal radiation level of 1,600 BTUs/ hr-ft². 13 (5 kW/m^2) 14 A. A 2004 report prepared by ABSG Consulting Inc. for the FERC provides a 15 literature review documenting the effects of thermal radiation on both people and 16 structures. An excerpt from ABSG report table 2.6 is reproduced below to 17 emphasize the impact of exposure time on injury level to people at the thermal flux of 1600 Btu/hr-ft2 (5 kW/m2). 18

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Effects on People for 1,600 BTU/hr/ft² (5 kW/m²) Thermal Radiation

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	Exposure Ti me (se co nd	
Effect	3)	Data Source
Severe pain	13	Burn injury criteria from the Federal Emergency Management Agency (FEMA, 1990)
First-degree burns	20	5 kW/m ² for 20 seconds corresponds to a thermal dose of 100 kJ/m ²
Second-degree burns	30	5 kW/m ² for 30 seconds corresponds to a thermal dose of 150 kJ/ m
	40	FEMA, 1990
Third-degree burns (1% fatality)	50	50 seconds corresponds to a thermal dose of 250 kJ/m
72% probability of first- degree burns	40	TNO (1992) probit equation

From the above table, it is obvious that the level of 1,600 BTU/hr/ft² (5 kW/m²) is only

protective provided that the potentially exposed population will have both

opportunity and capability to quickly take cover. It may also be protective to

workers or emergency personnel who are wearing protective clothing

This high thermal radiation level does not take into account sensitive populations,

such as the elderly, handicapped or children. It also does not account for

problems that startled people may encounter in the rush to escape to a protected

Exhibit	

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area. Further, it does not appear to take into account the extended duration that 1 2 the thermal flux from an LNG fire is likely to last. 3 Q. Could you describe the protective clothing that could serve to protect workers or 4 emergency personnel? 5 A. The protective equipment typically used by Fire Service personnel during rescue 6 operations from burning buildings includes heat reflective and insulative clothing. 7 Could residents in the immediate vicinity of an LNG terminal be issued similar Q. 8 clothing? 9 This is not a practicable solution to the problem of inadequate protection for a A. 10 number of reasons. Workers and emergency personnel can be trained to don the 11 protective clothing quickly, and correctly. Given the large number of residents 12 living in proximity to the proposed Weaver's Cove site, the difficulties of 13 providing adequate training would be enormous. Further, children, the elderly, 14 and the disabled simply cannot respond as quickly and as completely as can 15 workers and emergency personnel. Further, children grow; ensuring properly fitting protective clothing would be an administrative task of enormous 16 17 complexity and certain of failure. 18 Q. Are there any regulations, standards or recommended practices that provide for 19 exclusion zones or minimum separation distances with lower thermal radiation 20 limits that better provide protection for the public. 21 Yes. There are several well known standards that recommend lower thermal A. 22 radiation levels for the protection of people.

Exhibit

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US Department of Housing and Urban Development

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The Department of Housing and Urban Development (HUD) has established thermal radiation flux levels of 31.5 kW/m² (10,000 Btu/hr-ft²) for buildings and 1.4 kW/m² (450 Btu/hr-ft²) for people as guides in determining an "Acceptable Separation Distance" (ASD) between a fire consuming combustible liquids or gases and nearby structures and people. These HUD rules are codified in 24 CFR Part 51, Subpart C (paragraph 51.203) Safety standards. The following discussion from the preamble to the final HUD rule, 49 Fed.Reg. 5100 (February 10, 1984), helps to put the seriousness of this issue into context: People in outdoor areas exposed to a thermal radiation level of approximately 1.500 BTU/ft²- hr will suffer intolerable pain after 15 seconds. Longer exposure causes blistering, permanent skin damage, and even death. Since it is assumed that children and the elderly could not take refuge behind walls or run away from the thermal effect of the fire within the 15 seconds before skin blistering occurs. unprotected (outdoor) areas, such a playgrounds, parks, yards, school grounds. etc., must be placed at such a distance from potential fire locations so that the radiation flux level is well below 1500 BTU/ft²- hr. An acceptable flux level, particularly for elderly people and children, is 450 BTU/ft²- hr. The skin can be exposed to this degree of thermal radiation for a prolonged period of time with no serious detrimental effect. The effects at this exposure would be the same as a bad sunburn. Therefore, the standard for areas in which there will be people in exposed settings (e.g., outdoor recreation areas such as playgrounds and parks)

Exhibit

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1 will not exceed 450 BTU/hr. sq. ft. Areas covered also include open space 2 ancillary to residential structures, such as yard areas and vehicle parking areas. An excerpt from this HUD standard is contained in Exhibit B herein. Note that 3 the HUD rules specifically mention LNG as one of the hazardous materials that is 4 5 subject to the acceptable separation distance rule. 6 SFPE Handbook of Fire Protection Engineering 7 The Society of Fire Protection Engineers Handbook of Fire Protection Engineering 2nd Edition recommends a level of 800 Btu/hr-ft² (2.5 kW/m²) as a 8 public tolerance limit for exposure to radiant heat (see page 2-114). 9 10 **European LNG Regulations** 11 The European LNG rule, EN 1473:1997, defines the maximum allowable incident thermal radiation flux at the LNG property boundary as 5 kW/m for urban areas. 12 13 However, the European code defines a lower allowable thermal radiation level as 1.5 kW/m² for "critical areas". Examples of critical areas noted in EN 1473 are 14 15 areas which are difficult to evacuate on short notice. Therefore, the European 16 LNG rules require review of the areas that may be impacted by a major LNG fire 17 To emphasize the difference between US and European LNG codes, consider the 18 example of a stadium adjacent to the LNG facility. The NFPA thermal hazard exclusion zone, defined as "1600 Btu/hr/ft² (5000 W/m²) at the nearest point 19 located outside the owner's property line that, at the time of plant siting, is used 20

for outdoor assembly by groups of 50 or more persons for a fire over an

impounding area." The EN 1473 regulation specifically defines a stadium as a

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- 1 critical area, and therefore the European standard would be 480 Btu/hr/ft² (1.5
- 2 kW/m²) while the U.S. standard for this same area would be 1600 Btu/hr/ft² (5
- 3 kW/m²). Thus, the US thermal exclusion zone rules are considerably less than
- 4 their European counterpart.

5 The World Bank

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6 In the 1988 World Bank manual, "Techniques for Assessing Industrial Hazards",

7 the level of incident thermal radiation flux which causes no discomfort is listed as

1.6 kW/m². While this value is not a specific limit for site planning, it means that

the site evaluation should review the adjacent areas out to this limit to see if

special populations or critical facilities are impacted.

Thermal Radiation Recommendations in API 521

12 The American Petroleum Institute recommended practice 521 suggests

permissible exposure to the thermal radiation from flares listed in the table below.

14 Permissible Thermal Radiation Exposure for Flares from API 521 (1997)

Therma	Hazard	Adjacent area considerations for determination of the acceptable separation distance
BTU/hr- f t	kW/m ²	
500	1.6	at any location where personnel are continuously exposed
1,500	4.7	areas where emergency actions lasting several minutes may be required by personnel without shielding but with appropriate clothing

16 It is inconceivable that the permissible exposure to the public outside the facility property

line should be any less than the permissible exposure to personnel inside the plant.

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1 Q Would you extend the consideration of a lower thermal radiation hazard limit to 2 the LNG tanker route.

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- the LNG tanker route. Yes. Two recent government sponsored reports provided estimates of the distance to the 5 kW/m² (1600 BTU/hr-ft²) thermal flux level following an LNG release from an LNG tanker. The FERC revision of the ABSG report (table 4) estimates the distance to the 5 kW/m² thermal flux level as 5008 ft. Using the common point source approximation that incident thermal flux is proportional to the inverse square root of the target distance translates into about 1100 ft or almost 2 miles to the 1.5 kW/m flux level. The December 2004 Sandia report, titled "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water." estimates the distance to the 5 kW/m² thermal flux level as about 2000 meters (6560 ft) following an LNG release from an LNG tanker. Since Sandia used a zero wind speed in their analysis, the estimated thermal hazard impact distance using the DOT requirement of the largest local wind speed over 5% of the time would be expected to be an even greater distance. Nevertheless, again using the common point source approximation that incident thermal flux is proportional to the inverse square root of the target distance to the 1.5 kW/m² thermal flux level translates into over 21000 ft or almost 4 miles.
- 20 Q. What are your specific recommendations regarding thermal exclusion zones?

Exhibit	

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1	A.	The clear intent of Congress to protect people from a major LNG release requires
2		the consideration of a lower thermal hazard criteria (such as the 1.5 kW/m² value
3		used by the Europeans or the 1.4 kW/m² value used by HUD) for areas adjacent to
4		the facility and along the LNG tanker route which are inhabited by sensitive
5		populations or critical facilities.
6		Therefore, FERC should consider the areas that may be subjected to the 1.5
7		kW/m² thermal radiation flux level following a major LNG spill, either from an
8		LNG terminal or an LNG tanker.
9	Q.	Can you illustrate the errors that FERC and some of the LNG industry use to
10		justify refusing to consider the lower public thermal hazard zone.
11	A.	Yes. Recently the NFPA 59A committee rejected a proposal by the member
12		representing the views of the fire service to reduce the target thermal radiation
13		flux values to be in agreement with modern fire service ideas[].
14		The reasons that the NFPA 59A committee advances in defense of this decision
15		are preposterous. The following quotes are taken from the NFPA 59A white paper
16		(59A-05-ROC) defending the decision to reject the thermal flux reduction
17		proposal.
18		"such a level and duration are acceptable since a second degree burn is
19		reversible if attended to promptly"
20		" in a 30 second exposure a person can safely run away to a distance of 100 m
21		at which distance the radiant intensity will be far less and thus avoid suffering a
22		second degree burn"

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Exhibit ____

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2	Mode	rn safety analysis would not define burn injuries as acceptable. The argument that
3		the public can run away fast enough to avoid injury is equally ridiculous as it does
4		not consider the elderly, children, or the handicapped.
5		To illustrate how preposterous the above NFPA 59A white paper statements are,
6		consider that the same white paper noted that "NFPA 59A Standard stipulates 5
7		kW/m^2 (1,600 Btu/hr ft^2) as a safe level of exposure at a property line that can be
8		built upon next to a LNG storage facility"
9		Clearly the 5 kW/m ² (1600 BTU/hr-ft ²) thermal flux level can not be considered a
10		"safe level of exposure".
11		The NFPA 59A white paper further states, " most regulations, worldwide,
12		stipulate a level of 5 kW/m² as the acceptable level (for the purposes of facility
13		design and location) for public exposure to thermal radiation hazards from a
14		liquid hydrocarbon pool fire". The information on the HUD regulations,
15		European LNG rules and the World Bank recommendations presented previously
16		herein show that this statement is erroneous.
17		Although NFPA 59A continues to reject modern safety concepts, the FERC must
18	•	employ the most current safety ideas in order to fulfill their duty to protect the
19		public.
20	Q.	Does FERC apply the widely accepted principles of Process Safety in it's
21		deliberations and requirements?

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1	A.	No. The world wide process industry has embraced the process safety
2		management concepts, such as the principles documented by the American
3		Institute of Chemical Engineers. OSHA's Process Safety Management regulations
4		in 29CFR 1910.119 are a prime example of this concept. However, OSHA does
5		not have authority over LNG facilities, only because of the federal government
6		mandate that OSHA regulation is precluded if another federal agency has safety
7		regulations in place. Unfortunately this deference leaves outdated safety
8		regulations, such as the DOT LNG safety regulations in 49CFR193, in full force.
9		Other federal agencies with authority over segments of the process industry, such
10		as the US Mineral Management Services rules over the offshore petroleum
11		industry, have embraced process safety management concepts.
12		EPA, in 40 CFR68, expanded the process safety regulations to include impacts of
13		hazardous chemicals outside the facility fence line.
14	Q.	How would consideration of process safety management to proposed LNG
15		facilities help accomplish the goal of public safety?
16	A.	A safety management system that included formal hazard analysis would permit
17		continuing technical review of the level of safety within the LNG facility.
18		A recent technical paper by ABSG (a FERC contractor) detailed the need for
19		LNG facilities to be subjected to the safety management system concepts inherent
20		in process safety. A copy of this paper is contained in the Exhibit C.
21		FERC contracted with IoMosaic Corporation in September 2004 to evaluate the
22		cryogenic design review process and inspection program by which the FERC staff

Exhibit

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reviews proposed projects and ensures the continued operational reliability and 1 2 safety of each jurisdictional LNG import terminal and peak shaving facility. See 3 FERC solicitation number FERC04C40490. The scope of this project included: 4 An evaluation of the engineering and design information required of an applicant to file in its application under Title 18. Code of Federal Regulations Part 380.12 5 in Resource Report 13: and the subsequent review criteria used by the staff to 6 7 determine reliable and safe operations, and the adequacy of company operating 8 and maintenance practices: 9 A review of the staff's application of the design spill criteria used to establish 10 thermal radiation and flammable vapor exclusion zones at LNG facilities An assessment of whether there are additional safety features or plant 11 components that should be examined during inspections and/or application 12 13 reviews; An assessment of international construction, operation, and maintenance 14 standards and/or regulations, e.g., in Japan or Europe, that offer better 15 16 protection and/or operating and maintenance measures/standards. An evaluation of the Cryogenic Design and Inspection Manual prepared during 17 the design review of proposed facilities and subsequently used to evaluate facility 18 19 operation: including whether there are additional facets of plant operations. 20 maintenance procedures, or procedures that should be examined. Even though the contract deliverable report was submitted in late January 2005. 21 FERC has never released the report. As a frequent contributor to the process 22

Exhibit

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1 safety literature, it has been expected that IoMosaic would include process safety 2 management recommendations in their report to FERC. The importance of this 3 report is that it covers some of the concerns that have been raised herein. 4 Q. Why do you believe that FERC safety analysis uses inappropriate consequence 5 models? 6 A. Dr. Havens has detailed the FERC's incorrect use of the plug flow vapor hold-up 7 model for the evaluation of vapor dispersion exclusion zone evaluations. For the 8 case of vapor dispersion exclusion zone evaluations for the process areas 9 impoundment areas, FERC has opted to use the old NFPA definition rather than 10 the previous DOT 193 "§Sec. 193.2059 requirements. The result is that the 11 "design LNG spill" in the FERC analysis is significantly less than the equivalent 12 "design LNG spill" which would result from the previous DOT 193 "&Sec. 13 193.2059 requirements, with the ultimate effect that the FERC vapor dispersion 14 exclusion zone estimates are too small. The appendix to Dr Zinn's paper 15 presented at the recent LNG safety sessions of the American Institute of Chemical 16 Engineers conference details this FERC error. A copy of the Zinn detail 17 discussion is Exhibit D. Dr. West, if the Commission were to accept your concerns and challenges, would 18 Q. 19 it not have to reach the conclusion that it is not possible to certificate any LNG project? 20 Absolutely not. However, in the post 9/11 world it is prudent to insure the public 21 A. 22 against severe consequence events. This translates into locating LNG facilities at

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- 1 a sufficient distance from the adjacent public to insure that catastrophic events
- will not compromise their safety.

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UNITED STATES OF AMERICA BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION

Weaver's Cove Energy, L.L.C. and)	Docket Nos. CP04-36-000, CP04-41-000,
Mill River Pipeline, L.L. C.	<i>)</i>))	CP04-42-000, and CP04-43-000

DECLARATION OF WITNESS

I, Harry West, declare under penalty of perjury that the statements contained in the Prepared Direct Testimony of Harry West on behalf of the City of Fall River and the Attorney General of the Commonwealth of Massachusetts in this proceeding are true and correct to the best of my knowledge, information, and belief.

April Wall

Executed on this 3rd day of June, 2005.

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Exhibit

page 1

Consulting Chemical Engineer

Summary Resume

SUMMARY OF EXPERIENCE

Over thirty years experience in consulting and technical project management for the oil, gas, water, chemical, and pipeline industries, with particular emphasis on process safety automation technologies.

EDUCATION

Bucknell University, B.S. Chemical Engineering Oklahoma University, Ph.D. Chemical Engineering

EXPERIENCE

1986 - present

CONSULTING CHEMICAL ENGINEER

Engineering consultancy with emphasis on the evaluation of developing safety and environmental technologies for venture capital considerations, application of Process Safety Management systems for pipeline, oil & gas facilities and forensic investigation of catastrophic chemical accidents.

ADJUNCT PROFESSOR OF CHEMICAL ENGINEERING, TEXAS A&M

Directing graduate research and conducting Process Safety short courses through the Continuing Education Center, within various Companies, and at AIChE meetings.

1980 - 1986

ENGINEERING DESIGN GROUP

President of engineering subsidiaries, Corporate Director, and Principal Engineer

Dr. West was the technical leader of the management team which transformed EDG from a small engineering consultant to an international SCADA/DCS contracting firm with billings in excess of \$15MM per annum. Prior to the change to contracting, Dr. West was responsible for the full service engineering office in Houston, conducting projects in the petroleum, LNG/LPG, chemical, water, and pipeline industries. Additionally, Dr. West was responsible for establishing a Middle East operating subsidiary.

1977 - 1980

ENERGY ANALYSTS (renamed QUEST Consultants)

Co-founder, Principal Engineer, Board Chairman

EA was formed to provide consulting services for process safety automation and environmental monitoring systems. Dr. West directed the development of one of the first computer-based environmental monitoring stations. Process safety training services for petrochemical and gas facilities was also a significant part of the business. Consequence analysis and process hazards reviews were conducted for a wide variety of clients, including federally sponsored projects.

1970 - 1977

UNIVERSITY ENGINEERS

Principal Engineer

Dr. West provided engineering consulting services to the petrochemical and LNG/LPG industry. As a member of the LNG/LPG group, Dr. West was involved in over 30 peak-shaving or baseload LNG plants worldwide, ranging from conceptual design to regulatory approval to operational troubleshooting assignments. He was responsible for developing the running-film vaporizer from concept through ASME code certification to commercialization. Dr. West was the leader of a group that conducted energy and process safety audits for the process industry. Analysis of new processes for venture capital organizations was also among Dr. West's consulting assignments.

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Dr. Harry E. West

Consulting Chemical Engineer

Summary Resume page 2

UNIVERSITY OF OKLAHOMA - Flame Dynamics Laboratory

Under a concurrent appointment as adjunct Professor of Chemical Engineering, Dr. West was involved in graduate research supervision. Dr. West taught graduate courses in chemical process control.

1969 - 1970 CHEMSHARE CORPORATION

Member of Founding Staff

Dr. West was a member of the team responsible for development of the chemical process computer simulation program, DESIGN, one of the most widely used software products of its class, demonstrated by continuing popularity today. Continued part-time association, continuing today.

1968 - 1969 UNIVERSITY OF PITTSBURGH

Assistant Professor of Chemical Engineering

In addition to research and teaching chemical process control theory, Dr. West was concurrently involved as a consultant to Westinghouse Power Systems.

1965 - 1968 UNIVERSITY OF OKLAHOMA RESEARCH INSTITUTE

Graduate Assistant

Dr. West participated in several research projects involving control systems, including a thesis on optimal feedforward-feedback control.

1964 - 1965 MOBIL QIL

Process Engineer

As a summer intern, Dr. West was involved in simulation studies of process equipment at the Paulsboro refinery.

LICENSES & SOCIETIES

Registered Professional Engineer, Pennsylvania
Registered Professional Engineer, Texas
Certified Safety Professional (retired)
American Institute of Chemical Engineers
System Safety Society
National Academy of Forensic Engineers
Instrument Society of America
Oklahoma Energy Advisory Council
Texas A&M Process Safety Research Center

PUBLICATIONS

Over eighty technical papers in chemical process control, computer simulation, SCADA/DCS, LNG technology, process safety analysis, energy efficiency and reliability.

PATENTS

One patent on LNG tank fire control system One patent on Running film LNG vaporizer

Exhibit	

Dr. Harry H. West, P.E. Summary of LNG/LPG Project Experience

Dr. West began his engineering career with providing process control design, process hazards analysis, risk assessments, safety systems design reviews, and site safety audits for liquefied natural gas (LNG) and liquefied petroleum gas (LPG) facilities. During the past thirty-five years, he has provided process safety engineering services for peak-shaving & baseload production facilities, receiving terminals, storage, and transportation systems.

He has participated in many LNG/LPG project teams over the past decades, both domestically and internationally. Dr. West has participated in various phases of the LNG/LPG industry, including projects outlined below;

- Project Feasibility studies
 Process Simulation using ChemShare Design II
- Developed the Running-Film Cryogenic Vaporizer from concept to commercialization at Philadelphia Gas Works (500 MMSCFD)
- LNG Research projects

Tank Rollover/Vaporizer Stabilization
Fire Protection system design data
Fiberglas Cryogenic Tank Certification
Tanker Safety Protective Automation Systems

Process Safety projects

Process Hazards Analysis / QRA ESD and Fire Protection Systems Production Barge/Ice-Breaker Tanker

- Investigation of LNG/LPG release incidents
- Project Safety Evaluation for Government Permit.
- LNG/LPG process safety engineering short courses on both an open enrollment basis and for individual corporations.
- Pioneer in applying the developing concepts of quantitative risk assessment (QRA) during the early 1970's to LNG/LPG regulatory requirements.
- Assisted in U. S. Coast Guard project to define LNG/LPG marine regulatory framework.

Exhibit	

Current Texas A&M Process Safety Center LNG Projects

LNG Library

Based upon the donation of Professor C M Sliepcevich (research director of Constock Methane and director of the initial LNG technology developments in the 1950s), the library is soliciting hard to find papers and reports documenting LNG research and development.

LNG Release Source term definition

DEGADIS is only vapor dispersion model currently available which has been approved by DOT/NFPA, but does not have a source term. Problems which DEGADIS can not handle include: horizontal pressurized jet releases

Long trench pools, as required for analysis of transfer line leaks, process area leaks GRI SOURCE code was mentioned in 80s NFPA, but abandoned when many problems surfaced. GTI's SOURCE5 code still does not have material balance and therefore can be used incorrectly.

Verification of commercial LNG consequence modeling software

DOT mentions DEGADIS and FEM3A (but FEM3A is not available yet). Also note that one can use other software "approved by administrator".

Procedures to get OPS / DOE to approve other commercial models are being considered. Validation against both field test data and results of several specifically well defined sample scenarios (tanker spill, tank spill, process area spill; water vs. land cases, etc)

Need to identify specific maximum credible accident design spill parameters used most often in applications to regulatory agencies and for local community out reach (consider Canada & European rules too)

Dispersion Modeling using FLUENT Computational Fluid Dynamics

With the proposed use of CFD models for LNG vapor dispersion by DOE and others, MKOPSC proposes to extend the work done with FLUENT on pyrophoric chemical releases to LNG / LPG releases. This is particularly relevant since DOE has announced their internal CFD project also using FLUENT.

MKOPSC has used FLURENT in a graduate thesis concerned with pyrophoric silane dispersion.

Pool Fire Models

Large pool Fire

Need data on large fire columns to validate large LNG pool fire model, also determine if there is a size where air entrainment ratios become limited, hence causing smokey (less thermal radiative) fires

Current models are based upon very small scale experimental data

Biggest LNG spill on water was 40m³, but hazard analysts are extrapolating to 25,000m³ spills

Effect of composition on LNG fire thermal radiation

Suggest controlled experiments prior to large fire tests

Design a field of orifices with gas nozzles that we can spread apart, making bigger fire, more controllable experiment, design of experiment is underway

Later possible LNG spill fire tests may be considered.

Exhibit	

Vapor Dispersion Mitigation

Evaluation of vapor fences, water curtains, fog nozzles and other vapor dispersion mitigation techniques.

Use of infrared and LIDAR to activate Vapor Cloud / Fire protection systems

Fire Protection

Survey of LNG fire fighting

Peak shaving / baseload production / import terminals / truck loading stations / satellite peaking stations / marine dock issues

Training facilities / Brigade issues

Review Effectiveness of Low, Medium and High Expansion Foam

Under what conditions does it blow away? Does it help in larger areas or not?

Get data for engineering fixed system design at fire school tests

Research parallel to fire training to validate design parameters for engineering design of fixed dry chemical fire fighting

Note that all the work on establishing LNG fire fighting application rate data for dry chemicals and high expansion foam in 70s and 80s and now with new chemicals and equipment, industry needs to update application rate data.

Research to determine protection effectiveness of foamed polystyrene insulation in fire situations, including the effect of thermal radiation barriers

Similar research on ablative coating fire protection systems, including survey of current long term users.

Comparison and review of LNG regulations

Compare DOT with forthcoming NFPA 59A

Expand this comparison to include European code EN 1473, Canadian special conditions, Australian, Korean and Japanese practice.

There are many non-OPS regulated peak shaving facilities in USA that are under the OSHA PSM and NFPA rules (not DOT 193), requiring comparisons and suggested solutions to conflicts

LNG/LPG text book

Updating current text for use in two semester course for Qatar campus

Oatar LNG / LPG Fire School,

Coupled with the academic program (no fire protection school in the middle east)

LNG Water Vapor Explosion or Rapid Phase Transformation

Review current research projects and theories. Test Gaz deFrance computer model against controlled experiments

Aerosol Formation, Prediction And Laboratory Measurements

Continue current research, extending to cryogenic fluids

Larger scale tests emphasizing electrostatic ignition conditions and methods to reduce static charge potential or drop formation

Alarm Management

Continue defining alarm management techniques, particularly combining HAZOP and Alarm priority studies. Per API 14C concept, apply SAFECHART methodology to LNG unit operations

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(refrigeration, vaporizer, marine transfer, etc). Then couple with Alarm priority, grouping suggestions

Vehicle Fuel

Update on status of LNG technology and safety issues in utilization as vehicle fuel

LNG SIS database

Survey to update GRI's historical failure rate database (last data in 1980s). Unit operations fault tree models.

Benchmarking LNG practice

Similar to the surveys conducted for PSM practice.

NOX control concepts for Submerged Combustion Vaporizers

Cooler bath means ammonia NOX control is not efficient. Current designs of >40 ppm NOX are not within regulatory guidelines.

Rollover Modeling

Due to European regulations suggesting Rollover models to avoid excessive (100 x normal boiloff) handling capability. Sensitivity / SIS data on LNG linear temperature probes & densitometers. Mixing efficiency models for circular and rectangular tanks. Effectiveness of bottom mixing jets and proposed vapor injection systems.

Exhibit	

LNG/LPG Project Experience

Baseload Peak-shaving

North Africa Philadelphia Gas Works

Sonatrach terminal A
LNG-1 terminal B

LNG-2

Camel Boston Gas Skikda Lowell Gas

Indonesia

Huffco-Badak Baltimore Gas & Electric

Mobil-Arun
Minnegasco

Europe

Zeebrugge Atlanta Gas Light

USA Texas Eastern

Trunkline

CovePoint Iowa Public Service Savannah

Union Carbide

Abu Dhabi

Das Island Owens-Corning

Taiwan Conoco Dubai

India; Dhabol

Exxon Schutte Creek

Proposed Projects

Nigeria-Bonny Lynn
Canada-Artic Pilot
Trinidad-Corpus Christi (Amoco/Tesoro/NPLA)
'USA-SoCalGas-3

Exhibit	

The Department of Housing and Urban Development (HUD) rules on determining an "Acceptable Separation Distance" (ASD) between a fire consuming combustible liquids or gases and nearby structures and people

(24 CFR Part 51, Subpart C (paragraph 51.203) Safety standards.

The following standards shall be used in determining the acceptable separation distance of a proposed HUD-assisted project from a hazard:

- (a) Thermal Radiation Safety Standard. Projects shall be located so that:
- (1) The allowable thermal radiation flux level at the building shall not exceed 10,000 BTU/sq. ft. per hr.;
- (2) The allowable thermal radiation flux level for outdoor, unprotected facilities or areas of congregation shall not exceed 450 BTU/sq. ft. per hour.
- (b) Blast Overpressure Safety Standard. Projects shall be located so that the maximum allowable blast overpressure at both buildings and outdoor, unprotected facilities or areas shall not exceed 0.5 psi.
- (c) If a hazardous substance constitutes both a thermal radiation and blast overpressure hazard, the ASD for each hazard shall be calculated, and the larger of the two ASDs shall be used to determine compliance with this subpart.
- (d) Background information on the standards and the logarithmic thermal radiation and blast overpressure charts that provide assistance in determining acceptable separation distances are contained in appendix II to this subpart C.

[49 FR 5103, Feb. 10, 1984, as amended at 61 FR 13334, Mar. 26, 1996]

Appendix I to Subpart C of Part 51—Specific Hazardous Substances

The following is a list of specific petroleum products and chemicals defined to be hazardous substances under §51,201.

HAZARDOUS LIQUIDS Acetic Acid Acetic Anhydride Acetone Acrylonitrile Amyl Acetate Amyl Alcohol Benzene Butyl Acetate Butyl Acrylate Butyl Alcohol Carbon Bisulfide Carbon Disulfide Cellosolve Cresols Crude Oil (Petroleum) Cumene Cyclohexane No. 2 Diesel Fuel Ethyl Acetate Ethyl Acrylate Ethyl Alcohol Ethyl Benzene Ethyl Dichloride Ethyl Ether Gasoline Heptane Hexane Isobutyl Acetate Isobutyl Alcohol Isopropyl Acetate Isopropyl Alcohol Jet Fuel and Kerosene Methyl Alcohol Methyl Amyl Alcohol Methyl Cellosolve Methyl Ethyl Ketone Naptha Pentane Propylene Oxide Toluene Vinyl Acetate Xylene

Exhibit	

HAZARDOUS GASES Acetaldehyde Butadiene Butane Ethene Ethylene Oxide Hydrogen <u>Liquefied Natural Gas (LNG)</u> Liquefied Petroleum Gas (LPG) Propane Propylene Vinyl Chloride

Background Information Concerning the Standards

- (a) Thermal Radiation:
- (1) Introduction. Flammable products stored in above ground containers represent a definite, potential threat to human life and structures in the event of fire. The resulting fireball emits thermal radiation which is absorbed by the surroundings. Combustible structures, such as wooden houses, may be ignited by the thermal radiation being emitted. The radiation can cause severe burn, injuries and even death to exposed persons some distance away from the site of the fire.
- (2) Criteria for Acceptable Separation Distance (ASD). Wooden buildings, window drapes and trees generally ignite spontaneously when exposed for a relatively long period of time to thermal radiation levels of approximately 10,000 Btu/hr. sq. ft. It will take 15 to 20 minutes for a building to ignite at that degree of thermal intensity. Since the reasonable response time for fire fighting units in urbanized areas is approximately five to ten minutes, a standard of 10,000 BTU/hr. sq. ft. is considered an acceptable level of thermal radiation for buildings.

People in outdoor areas exposed to a thermal radiation flux level of approximately 1,500 Btu/ft2 hr will suffer intolerable pain after 15 seconds. Longer exposure causes blistering, permanent skin damage, and even death. Since it is assumed that children and the elderly could not take refuge behind walls or run away from the thermal effect of the fire within the 15 seconds before skin blistering occurs, unprotected (outdoor) areas, such as playgrounds, parks, yards, school grounds, etc., must be placed at such a distance from potential fire locations so that the radiation flux level is well below 1500 Btu/ft2 hr. An acceptable flux level, particularly for elderly people and children, is 450 Btu/ft2 hr. The skin can be exposed to this degree of thermal radiation for 3 minutes or longer with no serious detrimental effect. The result would be the same as a bad sunburn. Therefore, the standard for areas in which there will be exposed people, e.g. outdoor recreation areas such as playgrounds and parks, is set at 450 Btu/hr. sq. ft. Areas covered also include open space ancillary to residential structures, such as yard areas and vehicle parking areas.

(3) Acceptable Separation Distance From a Potential Fire Hazard. This is the actual setback required for the safety of occupied buildings and their inhabitants, and people in open spaces (exposed areas) from a potential fire hazard. The specific distance required for safety from such a hazard

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depends upon the nature and the volume of the substance. The Technical Guidebook entitled "Urban Development Siting With Respect to Hazardous/Commercial Industrial Facilities," which supplements this regulation, contains the technical guidance required to compute Acceptable Separation Distances (ASD) for those flammable substances most often encountered.

(b) Blast Overpressure:

The Acceptable Separation Distance (ASD) for people and structures from materials prone to explosion is dependent upon the resultant blast measured in pounds per square inch (psi) overpressure. It has been determined by the military and corroborated by two independent studies conducted for the Department of Housing and Urban Development that 0.5 psi is the acceptable level of blast overpressure for both buildings and occupants, because a frame structure can normally withstand that level of external exertion with no serious structural damage, and it is unlikely that human beings inside the building would normally suffer any serious injury. Using this as the safety standard for blast overpressure, nomographs have been developed from which an ASD can be determined for a given quantify of hazardous substance. These nomographs are contained in the handbook with detailed instructions on their use.

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Exhibit C

(Other ABS papers are included as Exhibit C to Haven's Testimony)

Exhibit ---

The Current Status of LNG Facility Standards and Regulations

Myron L. Casada ABS Consulting, Risk Consulting Division Donald C. Nordin ABS Consulting

AlChE Spring Meeting, April 2005 5th Topical Conference on Natural Gas Utilization Atlanta April 10-14, 2005

Abstract

With the large number of proposed liquefied natural gas (LNG) facilities in the United States (and worldwide), many new technical personnel are becoming involved in applying and interpreting LNG standards and regulations. Also, opponents of the new LNG developments are questioning whether existing safety and security requirements are adequate. In this paper, we will begin with an overview of existing standards and regulations pertinent to LNG facilities (for both onshore and offshore applications). That discussion will include documents from the National Fire Protection Association, the European Committee for Standardization, the Department of Transportation, and the United States Coast Guard. For offshore facilities, it will discuss the guidelines from some of the international classification societies. The paper will outline what is addressed (and what is not addressed) by these standards. The paper will then focus on and discuss the issues with those requirements and the changes that are currently under consideration by the standards organizations and federal regulators. The paper finishes with some specific recommendations for consideration by LNG facility developers.

Introduction

A key contributor to the safety of LNG facilities is the fact that they have, over the last 40 years, been built to some of the highest standards imposed in the petrochemical industry. These standards have matured and have been improved, even as they have been proven by the test of time. However, the industry has two major challenges facing it:

- Public opposition to traditional facilities, like onshore LNG import terminals
- Uncertainty about appropriate standards and regulations for nontraditional facilities, like LNG floating or fixed offshore import terminals

For traditional facilities, industry personnel need to have detailed knowledge of the appropriate standards, not only to implement them properly, but also to decide where a specific design in a specific location might need to exceed minimum standards. Also, if the public is going to have confidence in our ability to design, construct, and operate LNG facilities in its municipality, we need to be able to speak knowledgably about codes and standards when we interact with members of the public.

For offshore LNG terminals, regardless of their design, there are no industry standards or regulations that are as prescriptive or specific as those applicable to onshore facilities. Currently, the best sources of guidance for offshore terminal developers are the guidance

documents developed by the marine classification societies (e.g., the American Bureau of Shipping, Det Norske Veritas, and Lloyd's Register of Shipping). Even with those sources, offshore terminal developers face significant uncertainty as they prepare and submit applications to the regulators for approval. This regulatory uncertainty presents significant economic risk to the developers, even though they try to make what they believe are the right decisions for the long-term safety of the facility.

In this paper, we will examine each of the major standards and regulations pertinent to LNG facilities. The examination of each document will cover:

- Technical/design areas included
- Management systems requirements (if any)
- Risk-based features (if any)
- Expected or proposed changes (if any)

We will also make recommendations regarding steps that we believe facility operators should take that go beyond the requirements of current codes, standards, and regulations.

Onshore LNG Facilities

The primary standards and regulations that apply to onshore LNG facilities in the United States are:

- NFPA 59A Standard for the Production, Storage, and Handling of Liquefied Natural Gas
- EN 1473 Installation and Equipment for Liquefied Natural Gas Design of Onshore Installations
- 49 CFR Part 193 Liquefied Natural Gas Facilities: Federal Safety Standards
- 33 CFR Part 127 Waterfront Facilities Handling Liquefied Natural Gas and Liquefied Hazardous Gas

Each of these standards and regulations is discussed below.

NFPA 59A – Standard for the Production, Storage, and Handling of Liquefied Natural Gas. The National Fire Protection Association (NFPA) in the United States publishes NFPA 59A. The current version was issued in 2001, and an update is currently being prepared for release this year.

Technical/design areas included

NFPA 59A includes a wide variety of LNG facility considerations, including facility layout and spacing, process equipment requirements (e.g., for storage containers, vaporization facilities, piping systems, instrumentation and electrical equipment, LNG transfer equipment, fire protection equipment). The standard includes seismic design requirements for LNG facilities.

The standard also incorporates, by reference, codes and standards developed by a number of other organizations (e.g., American Society of Mechanical Engineers, the

American Society of Civil Engineers, the American Petroleum Institute, the American Concrete Institute, and the American Society for Testing and Materials).

Management systems requirements

NFPA 59A does not require any overall safety management system; however, there are requirements in the standard for safety, security, operations, maintenance, and training activities. There are also requirements regarding the competence of designers and fabricators. These requirements should lead a developer to implement typical safety management systems like (1) written safety programs, (2) operating procedures review and approval systems, (3) inspection, test, and preventive maintenance programs, (4) formal training programs, and (5) contractor evaluation and safety management.

Risk-based features

NFPA 59A does not require risk assessment nor does it suggest that risk techniques be used to define characteristics of the facility. However, it does require that consequence analyses be used to judge the acceptability of the facility and equipment siting. For example, the standard specifies maximum radiant energy levels and flammable vapor concentrations for specific scenarios (e.g., design spills and impoundment fires). Also, in several cases, it indicates that certain requirements of the standard can be altered if deemed acceptable to the "authority having jurisdiction." Preparation of any such submittals to the authority, using a risk-based decision-making approach, could increase the likelihood that such a submittal might be approved.

Expected or proposed changes

NFPA standards must be updated or revalidated at least every 5 years. The NFPA 59A committee has already met to prepare a new version to be released in 2005. No information regarding the nature of any proposed changes has been published yet.

EN 1473 – Installation and Equipment for Liquefied Natural Gas - Design of Onshore Installations. The European Norm standard EN 1473 was approved in 1997, based on an earlier British standard. Like NFPA 59A, it applies to onshore LNG facilities. However, it is a much more performance-based standard than NFPA 59A, allowing many of the design decisions to be made or justified based on the risk analyses that are required by the standard.

Technical/design areas included

The standard provides requirements for all of the types of LNG-related equipment typically found in a liquefaction plant, export terminal, import terminal, and other LNG storage locations. These requirements are presented in the body of the text and in normative (i.e., mandatory) appendices (which are provided for LNG tanks, pumps, vaporizers, and pipelines). A very useful "informative" (i.e., nonmandatory) Appendix H provides a description and illustrations of the various types of LNG storage tank designs (e.g., single, double, and full containment alternatives).

Management systems requirements

Unlike NFPA 59A, this standard explicitly requires implementation of a quality management system (QMS) and a safety management system (SMS). The QMS, which is required to meet ISO 9001, must apply to the design, procurement,

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Exhibit ___

construction, and operation phases of the facility. The SMS must address the information generated in the hazard assessment for the facility.

Risk-based features

EN 1473 requires that a hazard assessment be performed to evaluate potential accident events. The standard allows either a probabilistic or a deterministic approach for the hazard assessment. In the probabilistic approach, events are evaluated based on their expected frequency and consequence. Events that do not meet established acceptance criteria (which are suggested by example frequency categories, consequence categories, and a risk matrix provided in informative Appendices J, K, and L, respectively) require the development of risk mitigation measures.

In a deterministic approach, the standard requires identification of "credible hazards," determination of the consequences of those hazards, and justification of the measures necessary to control the risks of each hazard.

Analysis techniques that are specifically referenced by EN 1473 for use in a hazard assessment include:

- Hazard and operability (HAZOP) analysis
- Failure modes and effects analysis
- Event tree methods
- Fault tree methods

The Center for Chemical Process Safety (Ref. 1) and the American Bureau of Shipping (Ref. 2) both provide documents that describe these techniques in some detail.

Regardless of what method is used to perform the hazard assessment, Section 4.6 of the standard also mandates that the design be subjected first to a preliminary process flow sheet review and then to a HAZOP analysis (when approved piping and instrumentation diagrams are available). The standard requires updates of the HAZOP analysis when major changes occur and that a management of change process be implemented for lesser changes.

Expected or proposed changes

This standard has not been revised since 1997; however, because of its performance-based approach, it is not likely to require updating. The authors are not aware of any impending changes.

49 CFR Part 193 – Liquefied Natural Gas Facilities: Federal Safety Standards. The Part 193 regulation is based in large part on NFPA 59A (the 1996 version) and as such has requirements that are very similar to that document. It was issued and is maintained by the Office of Pipeline Safety (OPS) in the Research and Special Programs Administration (RSPA) in the Department of Transportation (DOT). The regulation is the responsibility of OPS because LNG facilities in the United States are closely associated with, and often operated by, interstate pipeline companies that are already regulated by OPS.

Technical/design areas included

The regulation covers siting requirements, design, construction, equipment, operations, maintenance, personnel qualifications and training, fire protection, and security.

Management systems requirements

Like NFPA 59A, the regulation does not explicitly require a safety management system; however, it requires control of activities that are typically controlled by a safety management system. In the United States, a process facility, like an LNG facility that handles large quantities of flammable liquids or gases, would typically be covered under the Occupational Safety and Health Administration (OSHA) process safety management (PSM) standard (29 CFR 1910.119) and the Environmental Protection Agency (EPA) risk management program (RMP) rule (40 CFR 68). However, both of those regulations specifically exempt facilities that are regulated under the DOT regulations in 49 CFR Parts 193 and 195. The result of this coordination of regulatory approaches is discussed in the conclusions to this paper.

Risk-based features

Like NFPA 59A, this regulation defines basis events that require consequence analyses, but does not require more comprehensive risk-based analysis approaches.

Expected or proposed changes

DOT has recently issued a rulemaking disestablishing the RSPA (Ref. 3). The new Pipeline and Hazardous Materials Safety Administration will manage regulations for hazardous materials transportation. Various other functions of RSPA will be handled by the new Research and Innovative Technology Administration. The changes came into effect on February 20, 2005.

One of the first things on the new organization's agenda will be the petition by the City of Fall River, Massachusetts, for DOT to revise its regulations to require the establishment of new "minimum safety standards" for the location of an LNG facility. Specifically, the petition requests that DOT add requirements, including:

- A 2,500-foot distance from an LNG facility to population centers of 1,000 people (or 250 people if the people are elderly or children)
- One mile distance from areas of 5,000 population
- A ban on closure of bridges required for hospital access
- A ban on facilities in locations where safety and security zone implementation is not practical

At the time this paper was prepared there was not formal response from DOT on how it was going to address this petition. The City of Fall River also submitted a similar petition to the United States Coast Guard (Coast Guard). That petition is described later in this paper.

33 CFR Part 127 – Waterfront Facilities Handling Liquefied Natural Gas and Liquefied Hazardous Gas. 33 CFR Part 127 is the Coast Guard regulation that governs waterfront import and export LNG facilities or other waterfront facilities handling LNG. Its jurisdiction runs from the carrier or barge unloading arms to the last valve before the LNG tank.

Technical/design areas included

Part 127 provides much of its design requirements by referencing NFPA 59A (in particular for siting and layout, LNG storage containers, piping systems, instrumentation

Exhibit ___

and electrical, and LNG transfer equipment). Part 127 also includes other additional requirements for piping systems, hoses, piers and wharves, layout and spacing, electrical power systems, lighting systems, communications systems, warning systems, and sensing/alarm systems. Part 127 also includes a security section that only applies to waterfront LNG and liquefied hazardous gas facilities. (Since July 2004, waterfront LNG facilities must also meet the requirements of 33 CFR Subchapter H discussed below.)

Management systems requirements

Part 127 does not mandate a comprehensive safety management system; however, it specifies that the facility operator provide a number of procedures and documents similar to those that are common to most safety management systems, including:

- Operations Manual
- Emergency Manual
- Pre-transfer Inspections
- Maintenance
- Training
- Firefighting and Emergency Response

Also, there are requirements in other Coast Guard regulations that require additional safety management measures, like the requirement to report and investigate incidents resulting in release of LNG.

Risk-based features

Part 127 does not include any specific risk-based design or operational approaches; however, Part 127.017 allows an operator to provide a written request to have alternative procedures, methods, or equipment standards considered by the Coast Guard. An effective way to provide written support for such a request would be to use one of the analysis techniques defined in the Coast Guard's Guidelines for Risk-based Decision Making. That document (which is available on the Coast Guard's Web site) describes procedures for use of techniques such as change analysis, relative ranking, or what-if analysis for consideration of safety equivalency.

Expected or proposed changes

The City of Fall River also submitted a petition to the Coast Guard regarding suggested changes in Coast Guard regulations related to LNG facilities. The petition suggests that the Coast Guard establish thermal exclusion zones and vapor dispersion exclusion zones for LNG vessels (moored or in transit) comparable to LNG facility zones. In the Federal Register of November 3, 2004, the Coast Guard requested public comment on the need for such rulemaking. Public input was due to the Coast Guard by February 1, 2005. At the time this paper was written there was no feedback from the Coast Guard regarding how it was going to respond to the petition. It is not clear that the Coast Guard will find rulemaking warranted. The Coast Guard has indicated (Ref. 4) that it is considering the information available from the ABS Consulting LNG consequence methodology study for the Federal Energy Regulatory Commission (Refs. 5 and 6) and the Sandia National Laboratory report (Ref. 7) on releases from LNG carriers as it is looking for ways to improve and help ensure the safety of LNG transportation.

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Offshore LNG Facilities

The ability and responsibility to regulate offshore terminals arises from the Deepwater Port Act of 1974 (DWPA) and is being jointly managed by the Coast Guard and the Maritime Administration (MARAD). Much of the information in this paper regarding regulation of offshore terminals came from recent testimony to Congress by Captain David Scott of the Coast Guard (Ref. 4).

Deepwater Port Act

The Coast Guard's authority to regulate deepwater ports (DWPs) is defined in the DWPA, and the regulations pertaining to the licensing, design, equipment, and operation of DWPs are provided in 33 CFR Parts 148, 149, and 150. Originally pertaining only to oil, the Maritime Transportation Security Act of 2002 (MTSA) added natural gas to the DWPA and shifted responsibility for licensing DWPs for natural gas (including LNG) from the Minerals Management Service to the Secretary of Transportation. The Coast Guard and MARAD have been formally designated by DOT to process license applications submitted under the DWPA.

Coast Guard Regulations

There are no current regulations that provide LNG-specific design requirements for offshore LNG terminals. Because offshore LNG terminals represent new concepts, the Coast Guard is applying a "design basis" approach rather than mandating a series of prescriptive requirements. Under a design basis approach, each concept is evaluated on its own technical merits, using relevant engineering standards and concepts that have been approved by recognized vessel classification societies and other competent industrial and technical bodies. Many of the codes and standards listed above for land-based installations are being used by Deepwater Port Applicants. When this is done, it is very important that the different risks and issues surrounding the offshore installation be identified. The use of a structured risk-based decision-making process will facilitate the identification of these issues and risks. One aspect of the DWPA is the solicitation for comments by other agencies with an interest in the facility. It is here that many of the land-based codes and standards will be invoked, due in part because of the familiarity that other agencies have with them. Being able to identify the offshore or project-specific issues related to the installation may help streamline this review process.

Classification Society Rules

The development of offshore LNG terminals is an example of technical innovation by industry. Associated with such innovation is the need to define design approaches that ensure that an acceptable level of safety and environmental protection is achieved. Classification societies have responded to the lack of existing standards for offshore terminals by developing new rules. The American Bureau of Shipping (ABS), Det Norske Veritas, and Lloyd's Register of Shipping have all developed preliminary rules, which are available to industry and the government as they define an approval process for these terminals. This paper uses the ABS Guide for Building and Classing Offshore LNG Terminals (ABS Guide) as an example of what these new documents provide (Refs. 8 and 9). The other societies' rules differ in some ways, but for sake of brevity, only the ABS Guide will be described.

Exhibit ___

ABS Guide for Building and Classing Offshore LNG Terminals. ABS published the first version of this guide in 2003 and has prepared several updates based on industry and government agency input.

Technical/design areas included

ABS's Guide provides criteria that cover both steel and concrete gravity-based structures, as well as floating systems. It includes design requirements for:

- Structures
- Containment Systems
- Position Mooring Systems
- Process Facilities
- Layout and Arrangements
- Hazardous Area Classification
- Process Support and Service Systems
- Electrical Systems and Installations
- Instrumentation and Control Systems
- Safety Systems

The ABS Guide provides both requirements for specific design features and the analytical approaches (e.g., dynamic analyses, strength analyses) that will be used to evaluate the system designs.

Management systems requirements

The ABS Guide does not include specific requirements for management systems.

Risk-based features

The ABS Guide requires that a risk assessment be performed to (1) identify significant hazards and accident scenarios that may affect the terminal and (2) consider the benefit of existing or potential risk control options. The objective of the risk assessment is to identify areas of the design that may require the implementation of risk control measures to reduce identified risk(s) to an acceptable level. To accomplish that objective, the risk assessment is required to be a systematic process that can identify situations where a combination or sequence of events could lead to undesirable consequences, such as property damage, threats to personnel safety, and environmental damage.

The risk assessment must consider, as a minimum, the following events:

- Damage to the primary structure due to extreme weather, impact/collision, dropped objects, helicopter collision, exposure to unsuitably cold temperatures, exposure to high radiant heat
- Fire and explosion
- Loss of primary liquid containment (for a duration to be determined based on an approved contingency plan)
- LNG leakage
- Release of flammable or toxic gas to the atmosphere or inside an enclosed space

- LNG containment roll over (i.e., thermodynamic instability due to LNG stratification)
- Loss of ability to offload LNG or discharge gas ashore
- Loss of any one critical component in the process system
- Loss of any single component in the station keeping/mooring system (for floating systems)
- · Loss of electrical power

The risk control options (prevention and mitigation measures) deemed necessary by the risk assessment are considered part of the design basis for the terminal.

The ABS Guide recommends that early in the project a risk assessment plan be developed, documented, and submitted for review prior to conducting the risk assessment. During review of the plan, an agreement will be reached on the extent of the classification society's participation and/or monitoring of project-related risk studies. The society's participation in and/or monitoring of key tasks (e.g., hazard identification meetings) is considered necessary in order to establish a minimum level of confidence in the risk assessment results.

Expected or proposed changes

ABS has been active in soliciting industry and government comments on the ABS Guide and as offshore terminal designs are submitted for review, it is likely that the ABS Guide will continue to be revised.

Conclusions

From the review of the current LNG codes, standards, and regulations it is clear there are gaps in the documents we currently have available for designing and regulating LNG facilities, both onshore and offshore, in the United States. We believe these gaps exist in the following areas:

- Lack of requirements for broad safety management systems.
- Limited application of risk-based tools and risk assessment
- Significant uncertainty regarding the regulatory approval process for offshore terminals

We would like to offer recommendations for consideration by organizations developing new LNG facilities that address each of these gaps.

Recommendation 1: Consider voluntary implementation of broad safety management safety systems.

EN 1473 explicitly requires the implementation of an SMS. However, the U.S. DOT regulations and NFPA 59A do not have similar requirements. Also, because of the exemption for facilities regulated under 49 CFR Part 193, the OSHA PSM and EPA RMP regulations do not apply to U.S. LNG facilities. However, we believe that effective implementation of such systems (or similar SMSs) can contribute to long-term safety of LNG facilities and should be considered by terminal developers, even though it is not required.

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Recommendation 2:

Consider using risk assessment methodologies for LNG facilities as a tool to help evaluate facility design, operations, and maintenance.

This is also a requirement of EN 1473 and is included in the ABS Guide as an important design process step. In addition, it is recommended by the Society for International Gas Tanker and Terminal Operators (SIGTTO) in its document LNG Operations in Port Areas – Recommendations for the Management of Operational Risk Attaching to Liquefied Gas Tanker and Terminal Operations in Port Areas (Ref. 10).

Recommendation 3:

Consider working closely with the Coast Guard and MARAD as they continue to define the technical requirements for and the process under which additional offshore terminals will be approved.

At the time this paper was written, two offshore LNG terminals have been approved. However, because the technology is changing rapidly, additional terminal designs are likely to present different problem in the licensing process. Whether the process uses the classification society guidance documents or depends solely on a Coast Guard "design basis approach," input by all stakeholders is going to be an important part of moving the regulatory development and approval process along.

Biographies

Myron L. Casada, P.E.

Mr. Casada is Vice President of Marine, Offshore, Ports and Terminals for ABS Consulting and has over 30 years of engineering and risk assessment experience. Mr. Casada has provided extensive consulting in the risk-based decision-making and risk assessment areas for government agencies, including the Coast Guard, the Defense Department, and the Nuclear Regulatory Commission. He has been involved in ABS Consulting's support to the Coast Guard in the areas of risk-based decision making, facilitating projects involving the safety of liquefied natural gas transportation in U.S. ports, security threats to hazardous materials shipping, and safety in drill rig movements.

He also has coordinated much of ABS Consulting's support to the maritime industry in meeting the IMO International Ship and Port Facility Security Code, having helped write both ABS's Ship Security Guide and ABS Consulting's Port Security Guide.

Mr. Casada holds a B.S. degree in engineering and an M.S. degree in engineering administration (with a concentration in system reliability and risk assessment), both from the University of Tennessee.

Donald C. Nordin

Mr. Nordin has 18 years of experience in the marine, offshore and fabrication arenas. As a Senior Consultant with ABS Consulting, he acts as a primary liaison with clients to develop solutions to complicated engineering problems.

In the LNG arena Mr. Nordin has performed studies to identify the risks associated with the development of offshore LNG facilities. He has been involved with the development of offshore LNG facilities from project conception through the regulatory filing process and remains involved with these projects as they progress. He has performed the studies necessary to select an appropriate site for the development of an offshore LNG facility based on a set of project performance goals. He has performed risk analysis and design reviews of ports and marine and offshore structures associated with oil and gas production and LNG. Mr. Nordin has conducted risk assessments for a variety of marine applications, including serving as a subject matter expert and marine systems coordinator for the development of ABS's integrated tanker risk model.

Mr. Nordin holds a bachelor of science degree in marine engineering and is a Coast Guard Licensed Third Assistant Engineer for Steam and Motor vessels, unlimited horsepower.

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Biography of Speaker

Mr. Casada (pronounces name like "Canada") is currently Vice President for Marine, Offshore, Ports, and Terminals at ABSG Consulting Inc. in Houston, a risk management and engineering consulting firm affiliated with the America Bureau of Shipping.

In that role, he is responsible for structuring projects to support clients in the LNG and related industry sectors, with current efforts underway that include risk assessment, consequence analysis, marine engineering, site evaluation, seismic qualification, and regulatory compliance assistance. Mr. Casada has 30 years experience in the risk assessment and safety consulting industry. For the last 10 years he has been involved in ABS Consulting's support to the United States Coast Guard's risk-based decision-making program, including Coast Guard projects involving LNG operational plans, consequence analyses, and security assessments.

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<u>APPENDIX</u>

Recent Controversy Over Vapor Dispersion Exclusion Zone Estimates

The estimation of LNG vapor cloud exclusion distances in the USA LNG DOT193 regulations (49CFR193) requires modeling the hazard scenarios of LNG flowing into spill containment sumps and storage tank diked areas. Exclusion distances are demanded to meet the public safety intent of Congress.

In several recent FERC published DEIS documents, the exclusion zone calculations resulting from a spill into a vaporization area and transfer area may have been substantially underestimated due to FERCs misunderstanding of DOT 193 rules.

The pre 2000 DOT193 rules, in no uncertain terms, specified that the exclusion zone estimates for all LNG spill secondary containment areas be based upon Vaporization results from the spill caused by an assumed rupture of a single transfer pipe (or multiple pipes designed to deliver the same flow) which has the greatest overall flow capacity, discharging at the maximum potential capacity

The exact same spill concept is used to define the spill containment volume.

The 1998 NPRM which proposed to harmonize the DOT193 and NFPA59A language did not propose reducing the exclusion zone calculation requirement for the vaporization and transfer area spill containment to the NFPA59A "accidental leakage source" There was no mention of this deletion in the NPRM. Unfortunately, there was an inadvertent language error in the final DOT193 Amendment announcement in the March 2000 Federal Register., which lead to ambiguity in this specific area.

But the DOT made it absolutely clear in their NPRM announcement and the DOT193 Amendment announcement that they did intend to maintain the current level of safety.

In fact, FERC does point out in their DEIS documents that some confusion on the design spill for vaporizer area exists, but due to their lack of co-ordination with DOT Office of Pipeline Safety technical staff, they appear to have misrepresented DOT intention. Furthermore, Some FERC DEIS documents do not provide transfer area exclusion zone estimates as required by DOT code.

For the vaporization area spill containment, FERC has used the older NFPA59A concept of an accidental spill from an "accidental leakage source". This has been defined by FERC to be an LNG spill from the rupture of a 1" to a 3" connection. The DOT193 intent would demand the LNG spill rate from the largest pipe at full capacity. This spill rate would be the same as the 10 minute spill used to size the containment volume.

DOT has noted some other ambiguities in the March 2000 Amendment, as evidenced by the corrections to the 193.2005 section recently published on 10 March 2004 in the Federal Register.

Pertinent details of the pre 2000 DOT 193, the December 1998 NPRM and the March 2000 Amendment are contained herein.

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The pre-2000 DOT 193 code specifically stated:

- "§Sec. 193.2059 Flammable vapor-gas dispersion protection.
- (c) Computing dispersion distance. A minimum dispersion distance must be computed for the impounding system.
- (d) Vaporization design rate. In computing dispersion distance under paragraph (c) of this section, the following applies:
 - (1) Vaporization results from the spill caused by an assumed rupture of a single transfer pipe (or multiple pipes that lack provisions to prevent parallel flow) which has the greatest overall flow capacity, discharging at maximum potential capacity,"
 - i) The rate of vaporization is not less than the sum of flash vaporization and vaporization from boiling by heat transfer from contact surfaces during the time necessary for spill detection, instrument response, and automatic shutdown by the emergency shutdown system but, not less than 10 minutes, plus, in the case of impounding systems for LNG storage tanks with side or bottom penetrations, the time necessary for the liquid level in the tank to reach the level of the penetration or equilibrate with the liquid impounded assuming failure of the internal shutoff valve.
 - (ii) In determining variations in vaporization rate due to surface contact, the time necessary to wet 100 percent of the impounding floor area shall be determined by equation C-9 in the report ``Evaluation of LNG Vapor Control Methods," 1974, or an alternate model which meets the requirements of paragraphs (ii) through (iv) in Sec. 193.2057(c)(2).
 - (iii) After spill flow is terminated, the rate of vaporization is vaporization of the remaining spillage, if any, from boiling by heat transfer from contact surfaces that are reducing in area and temperature as a function of time.
 - (iv) Vapor detention space is all space provided for liquid impoundment and vapor detention outside the component served, less the volume occupied by the spilled liquid at the time the vapor escapes the vapor detention space.
 - (2) The boiling rate of LNG on which dispersion distance is based is determined using the weighted average value of the thermal properties of the contact surfaces in the impounding space determined from eight representative experimental tests on the materials involved. If surfaces are insulated, the insulation must be designed, installed, and maintained so that it will retain its performance characteristics under spill conditions.
 - (e) Planned vapor control. An LNG facility need not have a dispersion exclusion zone if the Administrator finds that compliance with paragraph (a) of this section would be impractical and the operator prepares and follows a plan for controlling LNG vapor that is found acceptable by the Administrator. The plan must include circumstances under which LNG vapor is controlled to preclude the dispersion of a flammable mixture from the LNG facility under all predictable environmental conditions that could adversely affect control. The reliability of the method of control must be demonstrated by testing or experience with LNG spills.

The 22 December 1998 NPRM contained the exact same paragraph §(d)(1) language, but proposed to eliminate the complex insulation of contact surface conditions.

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"§Sec. 193.2059 Flammable vapor-gas dispersion protection.

(c) * * *

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- (2) Dispersion conditions are a combination of those which result in longer predicted downwind dispersion distances than other weather conditions to the site at least 90 percent of the time, based on U.S. Government weather data, or as an alternative where the model used gives longer distances at lower wind speeds, Atmospheric Stability (Pasquill Class) F, wind speed = 4.5 miles per hour (2.01 meters/sec) at reference height of 10 meters, relative humidity equals 50.0 percent, and atmospheric temperature = 80 deg. F(27 deg. C).
 - (3) The elevation for contour (receptor) output H = 0.5 meters.
- (4) A surface roughness factor of 0.03 meters shall be used. higher values for the roughness factor may be used if it can be shown that the terrain both upwind and downwind of the vapor cloud has dense vegetation and that the vapor cloud height is more than ten times the height of the obstacles encountered by the vapor cloud.
 - (d) * * *
 - (1) Vaporization results from the spill caused by an assumed rupture of a single transfer pipe (or multiple pipes designed to deliver the same flow) which has the greatest overall flow capacity, discharging at the maximum potential capacity, in accordance with the following conditions:
 - (i) The rate of vaporization is not less than the sum of flash vaporization and vaporization from boiling by heat transfer from contact surfaces during the time necessary for spill detection, instrument response, and automatic shutdown by the emergency shutdown system but, not less than 10 minutes plus, in case of impounding systems for LNG storage tanks with side or bottom penetration, the time necessary for the liquid level in the tank to reach a level of penetration or equilibrate with the liquid impounded. In the case of storage tanks with an internal shutoff valve, the time necessary for spill detection and response of not less than one (1) hour must be used.

(2) If surfaces are insulated, the insulation must be designed, installed, and maintained so that it will retain its performance characteristics under spill conditions.

Unfortunately, after the code harmonizing project of 1999/2000, the same section of the 193 DOT code was changed to read;

§193.2059 Flammable vapor-gas dispersion protection.

...(c) The design spill shall be determined in accordance with section 2-2.3.3 of ANSI/NFPA 59A. [Amdt. 193-17, 65 FR 10959, Mar. 1, 2000]

Paragraph (d) was completely dropped. This is an obvious oversight error, since only a subparagraph was intended to be deleted per the NPRM.

The NFPA59A (2001) equivalent section 2-2.3.3 referenced above specifically stated:

§2.2.3.3 The spacing of an LNG tank impoundment to the property line that can be built upon shall be such that, in the event of an LNG spill specified in 2.2.3.5, an average concentration of methane in air of 50 percent of the lower flammability limit (LFL)

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does not extend beyond the property line that can be built upon, in accordance with calculations using one of the following:

- ..(a) ... DEGADIS...
- ..(b) ... FEM3A..
- ..(c) A model that incorporates the following:
 - (1) Takes into account physical factors influencing LNG vapor dispersion, including, but not limited to, gravity spreading, heat transfer, humidity, wind speed and direction, atmospheric stability, buoyancy, and surface roughness
 - (2) Has been validated by experimental test data appropriate for the size and conditions of the hazard to be evaluated
 - (3) Is acceptable to the authority having jurisdiction

The computed distances shall include calculations based on one of the following:

- (1) The combination of wind speed and atmospheric stability that can occur simultaneously and result in the longest predictable downwind dispersion distance that is exceeded less than 10 percent of the time
- (2) The Pasquill-Gifford atmospheric stability, Category F, with a 4.5-mph (2-m/sec) wind speed

The computed distances shall be based on the actual liquid characteristics and the maximum vapor outflow rate from the vapor containment volume (the vapor generation rate plus the displacement due to liquid inflow).

The effects of provisions for detaining vapor or otherwise mitigating flammable vapor hazards (e.g., impounding surface insulation, water curtains, or other methods) shall be permitted to be considered in the calculation where acceptable to the authority having jurisdiction.

2.2.3.5 The design spill shall be determined in accordance with Table 2.2.3.5 Design Spill An excerpt from that table is:

For "impounding areas serving only vaporization, process and LNG transfer areas", the design spill is "the flow from any single accidental leakage source".

As an interesting sidelight, the NFPA language above, contains the word "ONLY". Hence sub impounding areas within storage tank dikes may not actually be covered by this language. Unfortunately, there is not language anywhere in either code that specifically covers the subdike issue.

Excerpts from the Amendments to DOT 193 published in the Federal Register Amdt. 193-17, 65 FR 10959, Mar. 1, 2000

... The incorporation by reference of this standard will allow the LNG industry to use the latest technology, materials, and practices while <u>maintaining the current level of safety.</u>

The current Federal safety standards for LNG facilities were developed as a requirement of the Pipeline Safety Act of 1979, now re-codified in 49 United States Code Section 60103. In 1979, Congress determined that the public would be better served if the US Department Of Transportation (DOT) developed its own standards for the LNG industry. Prior to July 1, 1976, no Federal standards for LNG facilities existed. The current standard, which addresses LNG facilities used in gas pipeline transportation, was issued as a Final Rule on February 11, 1980 [45 FR 9203] and now appears at 49 CFR Part 193. Between July 1, 1976, and February 11, 1980, LNG facilities were required to comply with ANSI/NFPA 59A (1972 edition) and Part 192.

A report issued on July 31, 1978, by the General Accounting Office titled "Liquefied Energy Gases" highlighted some of the safety concerns in the transportation and storage of LNG. Foremost among those were:

- (1) protection of persons and property near an LNG facility from thermal radiation caused by ignition of a major spill of LNG,
- (2) protection of persons and property near an LNG facility from dispersion and delayed ignition of a natural gas cloud arising from a major spill of LNG, and
- (3) reduction of the potential for a catastrophic spill of LNG.

RSPA identified many deficiencies in the pre-1980 LNG standards which needed to be corrected to reduce the potential for a region spill of LNG and provide an acceptable level of safety. Because of the difference in format and the need for regulatory language to facilitate enforcement, a few sections of ANSI/NFPA 59A were rewritten for their adoption in Part 193.

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There have been significant changes in the ANSI/NFPA 59A since 1980. The 1996 edition of the ANSI/NFPA 59A includes the latest developments in LNG facility design and safety. Many of these developments have not been incorporated into current Part 193. The format and language of the ANSI/NFPA 59A has also changed significantly, over the years, to facilitate enforcement. ANSI/NFPA 59A is revised on a regular basis, and the revision process includes input from a wide variety of experts and a broad representation of interests.

RSPA has been very active in incorporating by reference voluntary consensus standards in its pipeline safety regulations. RSPA has participated for many years on several voluntary committees that develop consensus standards, including the ANSI/NFPA 59A technical committee. The existing Part 193 references provisions of ANSI/NFPA 59A in eight different locations. Recent amendments to the LNG regulations (February 25, 1997; 62 FR 8402 and August 1, 1997; 62 FR 41311) have brought Part 193 closer to ANSI/NFPA 59A. Unlike older editions of the ANSI/NFPA 59A, text in the current standard is in a regulatory format that makes it more suitable for incorporation by reference. RSPA is adopting the 1996 version of the ANSI/NFPA 59A. When the standard is revised in the future, RSPA will incorporate by reference the revised versions, as appropriate.

RSPA published an NPRM [63 FR 70737; December 22, 1998], proposing to replace most LNG requirements for siting, design, construction, equipment, and fire protection in Part 193 by referencing the American National Standards Institute (ANSI), National Fire Protection Association (NFPA) Standard 59A (1996 edition), titled "Standards for the Production, Storage and Handling of Liquefied Natural Gas (LNG)"

Section 193.2059 - Flammable vapor-gas dispersion protection

In the NPRM we proposed to:

- (1) retain minimum 10 minute spill duration for vaporization design rate;
- (2) delete planned vapor control;
- (3) retain 2.5% lower flammable concentration limit at the outer boundary of flammable vapor, and
- (4) add one hour time duration necessary for spill detection and response for tanks with an internal shutoff valve.

AGA, NEGA, NFPA, two operators and the Iowa Utility Board each offered comments against one or more of those requirements. AGA, NEGA and one operator commented that NFPA standard 59A does not set a 10 minute spill duration limit so that operators can take advantage of technology by using controls that can provide response time in less than 10 minutes.

NEGA said that by deleting planned vapor control to mitigate the emerging vapor from a design LNG spill increases burden on the operator and denies the operator alternative credit.

The Iowa Utility Board supported the proposal to retain the 2.5% lower limit for gas concentration. NFPA said that the 5% lower flammability limit is sufficient because the model takes concentration variations into account, and our requirement is too conservative.

One operator said there is no rationale for a one hour response time for spill detection for a tank with an internal shutoff valve.

Response

- (1) We agree with the commenters that with the current technology and control system operators can respond to spills in less than 10 minutes. We have revised this requirement to agree with the ANSI/NFPA 59A standard that 10 minute spill time can be reduced if the operator can demonstrate by instrument surveillance and emergency shutdown system that less than 10 minutes is needed to respond to spills.
- (2) We have deleted, as we proposed in the NPRM, the planned vapor control requirement from the regulations. We do not believe, any facility would opt for this alternative. In this final rule planned vapor control requirement will still be allowed as an alternative through a waiver.
- (3) We have retained the requirement for 2.5% lower flammable limit (LFL) concentration at the outer boundary of flammable vapor to provide a reasonable margin of safety. The DEGADIS model predicts only average concentration of LNG. Because vapor does not disperse uniformly, pockets of 5% LFL concentration could be adjacent to the average distance line predicted by the model. In other words, the model can under predict the actual concentration of LNG. Because many assumptions go in the formula, the distances predicted are not always accurate. Using a 2:1 safety margin was suggested by those who developed this model. On August 19, 1999, the NFPA 59A committee discussed this issue in great detail and voted to revise ANSI/NFPA 59A standard to require a 2.5% LFL in lieu of 5% LFL. Therefore, we see no need to revise the current concentration level in the regulations. In this final rule, we are allowing use of the FEM3A vapor dispersion model as an alternate to DEGADIS. The FEM3A model accounts for

additional cloud dilution which may be caused by the complex flow patterns induced by tank and dike structures. Dispersion distances are calculated in accordance with this model described in Gas Research Institute report GRI-96/0396.5, "Evaluations of Mitigation Methods for Accidental LNG Releases. Volume 5: Using FEM3A for LNG Accident Consequence Analyses."

(4) ANSI/NFPA 59A standard also requires a one hour duration for spills from tanks fitted with internal shutoff valves. We have referenced ANSI/NFPA 59A for determining design spills.

Proposed requirement on determining Vaporization design rate under 193.2059(d) has been deleted in this rule to allow operators more flexibility in computing.

Hence,

Section 193,2059 is amended to read as follows:

§ 193.2059 Flammable vapor-gas dispersion protection.

Each LNG container and LNG transfer system must have a dispersion exclusion zone in accordance with section 2-2.3.2 of ANSI/NFPA 59A with the following exceptions:

- (a) Flammable vapor-gas dispersion distances must be determined in accordance with the model described in the Gas Research Institute report GRI-89/0242, "LNG Vapor Dispersion Prediction with the DEGADIS Dense Gas Dispersion Model." Alternatively, in order to account for additional cloud dilution which may be caused by the complex flow patterns induced by tank and dike structure, dispersion distances may be calculated in accordance with the model described in the Gas Research Institute report GRI 96/0396.5, "Evaluation of Mitigation Methods for Accidental LNG Releases. Volume 5: Using FEM3A for LNG Accident Consequence Analyses". The use of alternate models which take into account the same physical factors and have been validated by experimental test data shall be permitted, subject to the Administrator's approval.
- (b) The following dispersion parameters must be used in computing dispersion distances:
- (1) Average gas concentration in air = 2.5 percent.
- (2) Dispersion conditions are a combination of those which result in longer predicted downwind dispersion distances than other weather conditions at the site at least 90 percent of the time, based on figures maintained by National Weather Service of the U.S. Department of Commerce, or as an alternative where the model used gives longer distances at lower wind speeds, Atmospheric Stability (Pasquill Class) F, wind speed = 4.5 miles per hour (2.01 meters/sec) at reference height of 10 meters, relative humidity = 50.0 percent, and atmospheric temperature = average in the region.
- (3) The elevation for contour (receptor) output H = 0.5 meters.
- (4) A surface roughness factor of 0.03 meters shall be used. Higher values for the roughness factor may be used if it can be shown that the terrain both upwind and downwind of the vapor cloud has dense vegetation and that the vapor cloud height is more than ten times the height of the obstacles encountered by the vapor cloud.
- (C) The design spill shall be determined in accordance with section 2-2.3.3 of ANSI/NFPA 59A.

To illustrate the DOT attempt to overcome recognized ambiguities resulting from the Harmonizing code effort.

Excerpts from the Federal Register: March 10, 2004 (Volume 69, Number 47) [Page 11338-11337]

Background

On March 1, 2000, we published a final rule document amending the safety regulations in 49 CFR part 193, which apply to LNG facilities used in gas pipeline transportation (65 FR 10950). That document replaced many part 193 siting, design, construction, equipment, and fire protection requirements with references to a consensus standard, NFPA 59A, "Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)" (1996 edition). Until then, part 193 referenced NFPA 59A (1996 edition) in only a few instances concerning siting, design, and fire protection.

An amendment to Sec. 193.2005, "Applicability," inadvertently implied that LNG facilities existing on March 31, 2000 (hereafter, "existing LNG facilities"), were exempt from part 193 operation, maintenance, and fire protection standards. After recognizing this ambiguity, we published a notice of proposed rulemaking (NPRM) to revise Sec. 193.2005 (68 FR 23272; May 1, 2003). In the NPRM, we also proposed to revise incorrect cross-references that resulted from the March 1, 2000, final rule to establish minimum standards for fire drills used in fire protection training, and to require that operators review their part 193 plans and procedures at least once a year. We further proposed to update all part 193 references to NFPA 59A to the 2001 edition of that standard.

Presenters Resume

Dr. Zinn (born and raised in Hope Arkansas like another famous American!) graduated with a PhD in Industrial Engineering from the University of Oklahoma. Thereafter, Dr. Zinn was a faculty member at the University of Texas. He is a registered Professional Engineer in Texas.

Dr. Zinn began his engineering career with providing process hazards analysis, risk assessments, safety systems design reviews, and site safety audits for liquefied natural gas (LNG) and liquefied petroleum gas (LPG) facilities with Energy Analysts (later renamed Quest) and then with Jones & Neuse of Austin Texas (later renamed RMT)

During the past thirty years, he has provided process safety engineering services for peaks having & baseload production facilities, receiving terminals, storage, and transportation systems, both domestically and internationally. Dr Zinn has taught LNG / LPG process safety courses worldwide.